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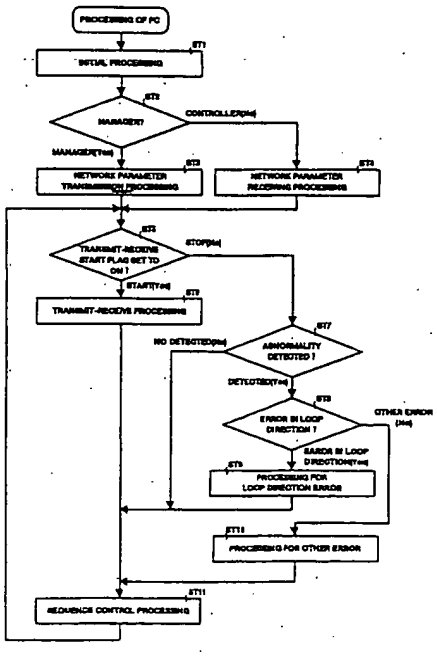
(54) Communication control method in network system based on duplex loop transmission system

(57) A network manager, when a transmission is requested from any FA equipment under control by the network manager, sets a flag indicating a loop direction for transmission in a transmission frame and transmits the transmission frame to other stations, and when network controllers receive the transmission frame with a flag indicating the loop direction set therein, the network controllers check whether the loop through which the transmission frame was actually received is the same as that indicated by the flag in the received transmission frame or not, and if it is determined that the loop through which the transmission frame was actually received is different from that indicated by the flag above, the network controllers send the transmission frame including an error report indicating the loop direction to the network manager.

FIG.3



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Description

FIELD OF THE INVENTION

The present invention relates to a communication control method in a network, and more specifically to a communication control method in a network based on a duplex loop transmission system in which a plurality of FA equipment such as programmable controllers are connected to each other with duplex loop configuration.

BACKGROUND OF THE INVENTION

Fig. 8A and Fig. 8B show configuration of a network system based on a duplex transmission system respectively. In this network, network units 20_1 to 20_4 are connected to four units of programmable controller (described PC hereinafter) 10_1 to 10_4 respectively, and the network units 20_1 to 20_4 are connected to each other with a duplex loop consisting of a main loop transmission path 30 and an auxiliary loop transmission path 40.

Of the network units 20_1 to 20_4, a network unit 20_1 functions as an administrative station, and in the following description the network controller 20_1 is sometimes described as a network manager (abbreviated as NM). In contrast, network units 20_2 to 20_4 are normal stations, and in the following description the network units 20_2 to 20_4 are sometimes described as a network controller (abbreviated as NC).

The NM 20_1 not only transmits signals to and receives signals from each of the PCs 10_1 to 10_4, but also transmits network parameters as to how many stations the network comprises, what type of communications is to be executed or the like to the NCs 20_2 to 20_4, and checks whether the network is operating correctly or not, while the NCs 20_2 to 20_4 transmit signals to and receive signals from the PCs 10_1 to 10_4 under management by the NC 20_1.

The difference between the NM 20_1 and NCs 20_2 to 20_4 is whether software mainly relating to a network management function has been installed therein or not, and the hardware configuration is identical.

Fig. 9 shows hardware configuration of a programmable controller having a network communication function. The PC 10 (PCs 10_1 to 10_4) comprises a CPU 11 executing sequence processing or processing for communications with the network unit 20 (NMs 20_1, NCs 20_2 to 20_4) or the like, a ROM 12 for storing a sequence program or a control program therein, a RAM 22 as a work memory handling various types of data, and external interface (I/F) 14 such as external input/output, serial interface, an LED, or a switch.

The network unit 20 comprises a CPU 21 executing communications with other stations or communication with the PC 10 for the network manager, a two-port RAM 22 which is a memory exchanging data or executing handshaking with the PC 10 for the network manager, a ROM 23 for storing therein processing programs such as communication programs, a RAM 24 as a work memory handling various types of data, and a network interface 25 connected to other stations with duplex loop configuration.

Connected to the network interface 25 are a main loop transmission cable 31 and a main loop receiving cable 32 each constituting a main transmission path 30, and an auxiliary loop transmission cable 41 and an auxiliary loop receiving cable 42 each constituting an auxiliary loop transmission path 40. Each of these cables is a two-core pair cable consisting of an optical cable or the like, and the main loop transmission cable 31 forms a pair with the auxiliary loop receiving cable 42, and the auxiliary loop transmission cable 41 forms a pair with the main loop receiving cable 32.

Fig. 10 shows an example of memory configuration of transmission/receiving interface in the two-port RAM 22 of the conventional network unit 20. The two-port RAM 22 comprises a transmission/receiving start flag area for storing therein a transmission/receiving start flag indicating whether an NM or an NC is ready for communications with other stations or not, a status area for storing a status indicating abnormality when transmission/receiving is stopped, a network parameter area for storing network parameters indicating how many stations the network comprise, what type of communications is to be executed, or the like, a transmit buffer for transmission from a PC, a receive buffer for receiving from an NM or an NC, each allocated therein.

Next description is made for operations in the conventional type of network.

At first description is made for the processing performed by the PC 10 with reference to Fig. 11. The PC 10 executes the initial processing for checking whether the RAM 13, external I/F 14, and network unit 20 are operating correctly or not (step ST141), whether the connected network unit 20 is a network manager or a network controller (step ST142).

As the network unit connected to the PC 10_1 is a network manager (NM 20_1), the PC 10_1 executes network parameter transmission processing for writing network parameters in a network parameter area of the two-port RAM 22 (step ST143). Then the network manager monitors the transmission/receiving start flag area of the two-port RAM 22, and determines whether transmission or receiving has been started or not according to whether the transmission/receiving start flag has been turned ON or not (step ST145).

If transmission or receiving has been started (step ST145 affirmative), transmission to or receiving from other stations is executed through a transmit buffer or a receive buffer allocated to the two-port RAM 22. Then the network manager executes processing for sequence control which is to be executed by a PC (step ST149).

On the contrary, if it is determined that the transmission/receiving flag has been turned OFF (step ST145

negative), the network manager checks contents of the status area of the two-port RAM 22 (step ST147), and if any abnormality is detected (step ST147 affirmative), appropriate processing for troubleshooting is executed (step ST148), and then executed is the sequence control processing to be executed by a PC (step ST149), and on the other hand if any abnormality is not detected (step ST147 negative), the network manager immediately executes the sequence control processing which is originally to be executed by a PC (step ST149).

If the sequence control processing is finished, system control returns to step ST145, and by repeating the processing sequence, the network manager executes sequence control as well as transmission to or receiving from other stations.

As the network controllers (NC 10_2 to 10_4) are connected to the PCs 10_2 to 10_4 respectively, in the PCs 10_2 to 10_4, a controller is selected according to a result of determination in step ST142, network parameters are fetched from the network parameter area of the two-port RAM 22 (step ST144). Then, like in the PC 10_1, processing is executed successively from the step ST145, and like in the PC 10_1, sequence control as well as transmission to or receiving from other stations are executed.

Next description is made for operations of the network manager (NM) 20 with reference to a flow chart shown in Fig. 12.

The NM 20_1 executes the initial processing such as checking whether the network I/F 25 is operating correctly or not (step ST100), and sets the transmission/receiving start flag stored in the transmission/receiving start flag area of the two-port RAM 22 to OFF (step ST101).

Then the NM 20_1 makes determination as to whether both the main and auxiliary loop cables are available for communication with other stations due to disconnection of a line or not (step ST102), and if it is determined that the line is not available for communication with other stations due to a failure such as disconnection of the line or for other reason (step ST102 affirmative), the NM 20_1 sets a line disconnection fault in the status area of the two-port RAM 22 (step ST106), also sets the transmission/receiving start flag in the two-port RAM 22 to OFF (step ST107), and repeats the processing sequence from step ST102 until the line is recovered to the normal state.

If it is determined that the status is normal (step ST102 negative), the network parameters stored in the network parameter area of the two-port RAM 22 are transmitted from the PC 10_1 to other stations (step ST104).

Then, to inform the PC 10_1 of the fact that communication with other stations has been started, the transmission/receiving start flag of the two-port RAM 22 is set to ON (step ST105).

Then whether a request for transmission has been issued from the PC 10_1 or not is checked in the transmit buffer of the two-port RAM 22 (step ST108), and if it is determined that a request for transmission has been issued (step ST108 affirmative), processing for transmission is executed (step ST109), and if it is determined that a request for transmission has not been issued (step ST108 negative), transmission processing is not executed, and system control shifts to step ST110.

Then checking is made as to whether a transmission frame has been received from other stations or not (step ST110), and if it is determined that a transmission/receiving frame has been received (step ST110 affirmative), the receiving processing for setting the received data in a receive buffer of the two-port RAM 22 is executed (step ST111), and if it is determined that any transmission frame has not been received from other stations (step ST110 negative), the processing for receiving is not executed, and system control shifts to step ST112.

Also checking is made as to whether any abnormality has been generated due to a failure such as disconnection of a line during transmission or receiving or not (step ST112), and if it it determined that any abnormality has not been generated (step ST112 negative), then system control returns to step ST108, and if it is determined that any abnormality has been generated (step ST112 affirmative), a flag indicating a line disconnection fault is set in the status area of the two-port RAM 22 (step ST106) with the transmission/receiving start flag in the two-port RAM 22 set to OFF (step ST107), and the processing sequence from the step ST102 is repeated until the line is recovered to the normal state.

Then description is made for operations of the network controllers (NC) 20_2 to 20_4 with reference to the flow chart shown in Fig. 13.

The network controllers 20_2 to 20_4 execute the initial processing such as checking as to whether the RAM 24 and network I/F 25 are operating correctly or not (step ST120), and set the transmission/receiving start flag stored in the transmission/receiving start flag area of the two-port RAM 22 to OFF (step ST121).

Then the network controllers check whether both the main and auxiliary loop lines are unavailable for communications with other stations due to such a failure as disconnection of a line or not (step ST122), and if it is determined that communication with other stations can not be executed due to such a failure as disconnection of a line (step ST122 affirmative), the network controllers set a flag indicating line disconnection fault in the status area of the two-port RAM 22 (step ST125) and also set the transmission/receiving start flag in the two-port RAM 22 to OFF (step ST126), and repeats the processing sequence from the step ST122 until the line is restored to the normal state.

If it is determined that the lines are in the normal state (step ST122 negative), the network controllers check whether network parameters from the NM 10_1 have been received or not (step ST124), and if it is determined that the parameters have not been received

yet (step ST124 negative), then system control returns to step ST122.

On the contrary, if it is determined that the parameters have been received (step ST124 affirmative), the network controllers execute the network parameter receiving processing for storing the network parameters in the network parameter area of the two-port RAM 22, and deliver the parameters to a PC connected to each of the network controllers (step ST127).

Then to report the fact that communication with other stations has been started to the PC connected to each network controller, the transmission/receiving start flag in the two-port RAM 22 is set to ON (step ST128).

Then the network controllers check whether a transmission frame has been received from other stations or not (Step ST129), and if it is determined that a transmission frame has been received (step ST122 affirmative), the network controllers execute the receiving processing for setting the received data in the receive buffer of the two-port RAM 22 (step ST130), and if it is determined that a transmission frame has not been received (step ST129 negative), the network controllers do not execute the receiving processing, and system control shifts to the step ST131.

Then the network controllers check whether a request for transmission has been issued from a PC connected to each of the network controllers by checking the transmit buffer of the two-port RAM 22 (step ST131), and if it is determined that a request for transmission has been issued (step ST131 affirmative), then network controllers execute the transmitting processing (step ST132), and if it is determined that a request for transmission has not been issued (step ST131 negative), the network controllers do not execute the transmitting processing with the system control shifted to the step ST133.

Then the network controllers check whether any abnormality has been generated due to such a failure as disconnection of a line during the communications described above or not (step ST133), and if it is determined that the line is in the normal state (step ST133 affirmative), system control returns to the step ST129, and if it is determined that any abnormality has been generated, the network controllers set a flag indicating a line disconnection fault in the status area of the two-port RAM 22, set the transmission/receiving start flag in the two-port RAM 22 to OFF (step ST126), and repeat the processing sequence from the step ST122 until the line is restored to the normal state.

In the conventional type of network system, checking is not executed as to through which of a main loop and an auxiliary loop a transmission frame has been received, and for this reason, as shown in Fig. 8B, even if a pair cable A between the NC 20_3 and NC 20_4 consisting of a main loop transmission cable 31 and an auxiliary receiving table 42 and a pair cable B between the NC 20_4 and NM 10_1 consisting of an auxiliary transmission cable 41 and a main receiving cable 32 are connected to the NC 20_4 erroneously, it can not be detected.

Even if the detection is impossible, not error is generated in the conventional system as described above, and normal communications can be executed, so that any problem does not occur, but generally in communications based on duplex loop configuration, if a main loop is disconnected, communication is executed only through the auxiliary loop, Also it is well known that, if power supply for any station is disconnected, a failsafe function enabling loop back in stations before and behind the failed station is used.

Such functions as described above naturally assume that the main and auxiliary loops are connected correctly, and if there are erroneous connections at a plurality of sections, such a problems as that the loop-back function does not work correctly occurs.

For this reason, to check that the main and auxiliary loops are connected correctly, markings are provided on cables or at the necessary places when the system is constructed, and visual checking for the markings is required, which is troublesome.

SUMMARY OF THE INVENTION

It is an object of the present invention to obtain a communication control method, especially a communication control method nor requiring any specific hardware configuration in a network system based on a duplex loop transmission system, in which, in a case where cables for main and auxiliary loops are connected correctly, transactions can be continued without being affected by normal communications, and in a case where cables for the main and auxiliary loops are not connected correctly, the loop fault can be detected, normal communications by a programmable controller can be stopped, and further an abnormal station in the loop direction, to which a cable is conceivably connected in an erroneous state, can be checked and this fact can be reported to a programmable controller, and further in a case where any abnormal station in the loop direction is detected, normal communications of the programmable controller can quickly be resumed, by periodically testing whether cable connection for all the stations has been restored to the normal state or not, at a point of time when the cable connection is restored to the normal state.

In the communication control method according to the invention described above, it is possible to check whether a cable is correctly connected thereto or not by checking a loop direction when an ordinary transmission frame is received.

In the communication control method according to the invention described above, when a cable is not correctly connected thereto, the network manager and all the network controllers can disable a request for transmission/receiving from any of FA equipment.

In the communication control method according to

the invention described above, the number of a faulty station is reported to the FA equipment connected to the network manager, so that it is possible to check which station is not correctly connected thereto with the cable.

In the communication control method according to the invention described above, the number of a faulty station is reported to the FA equipment connected to the network manager, so that it is possible to check which station is not correctly connected thereto with the cable.

In the communication control method according to the invention described above, it is possible to check whether connection of all the stations with the cable is corrected or not by periodically executing a loop direction test after the loop error is recognized.

In the communication control method according to the invention described above, when the connection of all the stations with the cable is corrected, an ordinary communication can quickly be restarted by instructing the fact that the error in the loop direction is corrected to the FA equipment.

Other objects and features of this invention will become understood from the following description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an explanatory view showing memory configuration of a two-port RAM in a network unit used for executing the communication control method according to the present invention;

Fig. 2 is an explanatory view showing a sequence of transmission/receiving in the communication control method according to the present invention;

Fig. 3 is a flow chart showing processing operations of the programmable controller in the communication control method according to the present invention;

Fig. 4 is a flow chart showing a first section of processing operations of the network manager in the communication control method according to the present invention;

Fig. 5 is a flow chart showing a second section of processing operations of the network manager in the communication control method according to the present invention;

Fig. 6 is a flow chart showing a first section of processing operations of the network controller in the communication control method according to the present invention;

Fig. 7 is a flow chart showing a second section of processing operations of the network controller in the communication control method according to the present invention;

Fig. 8A is a view showing configuration of a network system based on a duplex loop transmission system in which loops are correctly connected to each other;

Fig. 8B is a view showing configuration of a network system based on a duplex loop transmission system in which loops are incorrectly connected to each other;

Fig. 9 is a block diagram showing configuration of hardware of a programmable controller and a network unit;

Fig. 10 is an explanatory view showing memory configuration of a two-port RAM in a network system based on a conventional type of duplex loop transmission system;

Fig. 11 is a flow chart showing processing operations of a programmable controller in the network system based on the conventional type of duplex loop transmission system;

Fig. 12 is a flow chart showing processing operations of a network manager in the network system based on the conventional type of duplex loop transmission system; and

Fig. 13 is a flow chart showing processing operations of a network controller in the network system based on the conventional type of duplex loop transmission system;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Detailed description is made for Embodiments of the present inventions with reference to the related drawings.

Configuration of hardware of a network unit used in the method of controlling communications of a network system according to Embodiment 1 may be the same as that based on an example of the conventional technology shown in Fig. 9, and comprises a CPU 21 for processing of communication with other stations and executing communication with a PC 10 in a station, a two-port RAM 22 which is a memory for storing therein data transacted to and from the PC 10 in the station as well as for hand shaking with the PC 10, a ROM 23 for storing a processing program such as a communication program or the like, a RAM 24 as a work memory for handling various types of data, and a network interface (I/F) 25 connected to other stations with duplex loop arrangement.

Fig. 1 shows an example of memory configuration of the two-port RAM 22 of a network unit in Embodiment 1. A loop-directional faulty station number area for writing therein a loop-directional faulty station indicating a number of station in which an error in the loop direction according to a status in a status area is shown is allocated to the two-port RAM 22 in addition to a transmission/receiving start flag area, a status area, a network parameter area, a transmit buffer, and a receive buffer each the same as that based on the conventional technology.

The communication control method in a network system according to the present invention comprises the processing steps described below.

(1) A managing station (a network manager 20_1), when it receives a request for transmission, sets a flag indicating a transmitting loop direction (a main loop, an auxiliary loop) in a transmission frame, and transmits the frame to other station.

(2) An ordinary station (network controllers 20_2 to 20_4) checks, when it receives the transmission frame in which the flag indicating a loop direction is set from the managing station, coincidence between the loop actually received and the loop direction indicated by a flag indicated in the received transmission frame, and transmits a transmission frame including an error report indicating the number of station and the loop direction in which an error is detected to the network manager 20_1 to alert it in a case where the loop actually received is different from the loop direction indicated by the flag.

(3) The network manager 20_1 receives the transmission frame including an error report from any of the network controllers 20_2 to 20_4, or checks coincidence between the loop actually received and the loop direction indicated by a flag indicated in the received transmission frame, and in a case where the actually received loop is different from a loop direction indicated by the flag, the network manager disables a request for transmission/receiving from a programmable controller, and reports the number of a faulty station to the programmable controller.

(4) Also the network manager 20_1 receives the transmission frame including an error report from any of the network controllers 20_2 to 20_4, or, in a case where the actually received loop is different from the loop direction indicated by the flag, transmits a parallel-off instructing transmission frame for reporting an error in the cable connection of the network and the number of a faulty station in the network to all the network controllers 20_2 to 20_4.

(5) The network controllers 20_2 to 20_4 disables a request for transmission from a programmable controller when it receives the parallel-off instructing transmission frame from the network manager 20_1, and reports the number of faulty station to the programmable controller.

(6) The network manager 20_1 transmits a loop direction testing transmission frame for periodically executing testing as to whether a wiring fault has been corrected for each line to the network controllers 20_2 to 20_4 after it transmits the parallel-off instructing transmission frame to the network controllers 20_2 to 20_4.

(7) Each of the network controllers 20_2 to 20_4 checks the loop direction when it receives the loop direction testing transmission frame for each line from the network manager 20_1, and transmits the loop direction testing result transmission frame indicating a result of the check to the network manager 20_1.

(8) The network manager 20_1 checks the loop direction testing result transmission frame for each line of the network controllers 20_2 to 20_4, and transmits a parallel-on instructing transmission frame to each of the network controllers 20_2 to 20_4 and restarts a request for transmission/receiving from the programmable controller in a case where the error in all the stations and the loop direction of a station has been corrected.

(9) When each of the network controllers 20_2 to 20_4 receives the parallel-on instructing transmission frame, it restarts a request for transmission from the programmable controller.

Next description is made for flows of transmission/receiving between the NM 20_1 and the NC 20_2, NC 20_3, and NC 20_4 when any error occurs in the loop direction shown in Fig. 8B with reference to the view showing the operational sequence in Fig. 2.

At first, an ordinary transmission frame is transmitted from the NM 20_1 to the NC 20_4 in sequence SQ1. A flag indicating a loop direction is included in the transmission frame, and in a case where the frame is sent by, for instance, a main loop, the main loop is indicated in the flag, and it is sent through the main loop.

Then, in sequence SQ2, the NC 20_4 receives a transmission frame from the NM 20_1 through an auxiliary loop due to erroneous connection of the cable, so that an error occurs in the loop direction, and the NC 20_4 transmits a transmission frame including therein a loop direction error report to the NM 20_1.

In the example shown in Fig. 8B, an error in the loop direction occurs only in the NC 20_4, so that, in sequence SQ3, the NM 20_1 transmits a parallel-off instructing transmission frame to all the network control stations (ordinary stations) through the main loop to disable transmission to or receiving from other stations. Also in sequence SQ4, the NM 20_1 transmits a parallel-off instructing transmission frame to all the network control stations (ordinary stations) through the auxiliary loop to disable transmission therefrom or receiving thereby.

At this point of time, the $PC10_1$, $PC10_2$, $PC10_3$, and $PC10_4$ connected to the NM 20_1, NC 20_2, NC 20_3, and NC 20_4, respectively disable ordinary transmission and receiving, and then the NM 20_1 starts a loop direction testing.

At first, in sequence SQ5, the NM 20_1 transmits a loop direction testing transmission frame to the NC 20_2 using the main loop, and in sequence SQ6, the NC 20_2 transmits a loop direction testing result transmission frame, in this case, a normal result, to the NM 20_1. Similarly, in sequences from sequence SQ7 to sequence SQ10, the NC 20_3 and NC 20_4 are tested respectively. In this case, the NC 20_3 transmit[illegible] thereto, and the NC 20_4 trans[illegible] which an error has occurre[illegible]

Similarly, in se[illegible] sequence S[illegible]

tested respectively using the auxiliary loop. The NM 20_1 also tests a received direction of a station when it tests the loop direction in each of the cases respectively. In this case, the testing transmission frame does not reach the NC 20_2 and the NC 20_3, so that a time-out occurs in the test, in contrast the NC 20_4 transmits a result of the test in which an error has occurred therein to the NM 20_1.

A series of tests from sequence SQ5 to sequence SQ16 are periodically executed. In this case, each of the PC recognizes that a loop direction of the NC 20_4 is erroneous through a loop-directional faulty station number area in the two-port RAM 22, so that it is understood that cables A and B each connected to the NC20_4 are incorrectly connected thereto respectively. A user actually corrects the connection of the cables according to the incorrect connection described above.

After the connection is corrected, all the stations become normal in the test according to a series of main/auxiliary loops in the sequences from sequence SQ17 to sequence SQ28, and in sequence SQ29, the NM 20_1 transmits a parallel-on instructing transmission frame to all the network control stations using the main loop to restart the transmission/receiving.

Similarly, in sequence SQ30, the NM 20_1 transmits a parallel-on instructing transmission frame thereto through the auxiliary loop. At this point of time, the PC 10_1, PC 10_2, PC 10_3, and PC 10_4 connected to the NM 20_1, and the NC 20_2, NC 20_3, and NC 20_4 restart ordinary transmission/receiving, and start ordinary transmission in sequence SQ31 respectively.

Next description is made for operations of the PC, NM, and NC each for realizing a sequence of transmission/receiving as described above with reference to Fig. 3 to Fig. 7.

Fig. 3 shows an operating flow in each of the PCs (PC 10_1, PC 10_2, PC 10_3, and PC 10_4).

The PC 10 executes the initial processing whether the RAM 13, external I/F 14, and network unit 20 are correctly operating or not (step ST1), and determination is made as to whether the connected network unit is a network manager or a network controller (st

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nally to be processed by the PC is executed (step ST11), and system control returns to step ST5.

In contrast, in a case where the transmission/receiving start flag is set to OFF (step ST5, negative), contents of the status area in the two-port RAM22 is checked (step ST7), and in a case where the flag has been set to OFF due to any error (step ST7, affirmative), determination is made as to whether the error is one in the loop direction or not (step ST8).

If it is determined that the error is one in a loop direction (step ST8, affirmative), the error is regarded as a loop direction error, and a loop direction error processing such as reporting the loop-directional fault and the loop-directional faulty station number area or the similar information to a peripheral device often used under the control by the PC or a personal computer via the external I/F 14 is executed (step ST9). Then, the sequence control processing which is originally to be processed by the PC is executed (step ST11), and system control returns to the step ST5.

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ST10), then the sequence control proces
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ST11), and then system control returns to
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ST7, negative), after the step describe
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processed by the PC is executed (st
system control returns to step ST5

By repeating the processing above, the PC 10_1 repeats execu
sequence and transmission/rec

As the network controllers connected to the PC 10_2 to P trol unit is selected accor step ST2 in the PC 10 parameter is fetched f in the two-port RAM ing is executed succ the PC 10_1, and sion/receiving with PC 10_1.

Fig. 4 and Fi

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mined that the testing is complete (step ST44, affirmative), then testing for the auxiliary loop side is executed for all the stations including the station under control by the NM itself like that in the main loop side (step ST45, step ST46).

When the testing for both the main and auxiliary loops has been completed for all the stations, the NM 20_1 checks whether the error in the loop direction has been corrected in all the stations or not (step ST47), and if there is even one station in which the error has not been corrected (step ST47, negative), the NM 20_1 sets the current state in the loop-directional faulty station number area of the two-port RAM 22 (step ST52), reports how the cables are connected to the PC 10_1, and repeats the operations from step ST43 up to restore the state in the station to the normal one.

When the cables are correctly connected, and a result of the testing for both the main and auxiliary loops for all the stations is normal (step ST47, affirmative), the NM 20_1 transmits a parallel-on instructing transmission frame to all the NCs through both the main/auxiliary loops in order to report the recovery thereto (step ST48), turns OFF the number of the faulty station and the loop direction error internal flag each inside thereof (step ST49), clears the loop-directional faulty station number area of the two-port RAM 22 (step ST50), the description in the status area of the two-port RAM 22 is corrected to the normal to report the recovery to the PC 10_1 (step ST51), returns to step ST25 for setting the transmission/receiving start flag to a start, and then system control returns to the normal transmission/receiving state.

By repeating the operations described above, the network manager NM 20_1 executes communications with the PC 10_1 as well as with other stations.

Fig. 6 and Fig. 7 show an operating flow of the network controllers NC 20_2 to NC 20_4.

Each of the NC 20_2 to NC 20_4 executes an initial [illegible] such that the RAM 24 and the network I/F 25 [illegible] operate (step ST 60), and sets a transmis- [illegible] receiving start flag st[illegible] receiving start flag of [illegible] (step [illegible]

(step ST64), and if it has not received yet the parameter (step ST64, negative), system control returns to step ST62.

In contrast, if the NC has received the parameter (step ST64, affirmative), the NC executes processing for receiving of the network parameters for storing the network parameters in the network parameter area of the two-port RAM 22, and transfers the parameters to the station PC under control by the PC (step ST67).

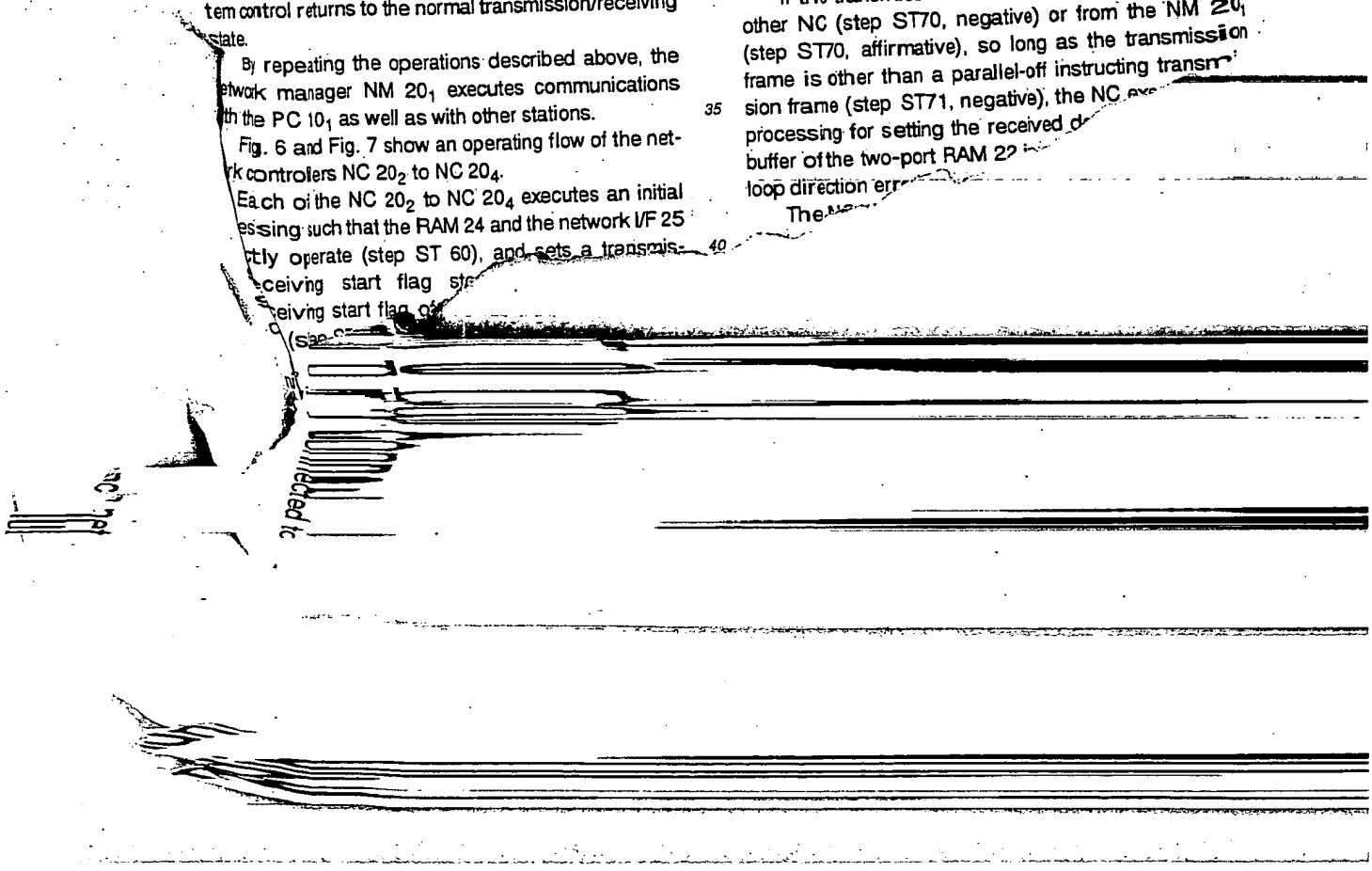
Then, a transmission/receiving start flag of the two-port RAM 22 is set to ON in order to report that communication with other station has been started to the station PC under control by the PC (step ST68).

Then, it is checked whether there is any received transmission frame from other station or not (step ST69), and if the NC has received a frame (step ST69, affirmative), the NC checks whether the received frame is from the NM 20_1 or not (step ST70). If any frame has been sent from the NM 20_1 (step ST70, affirmative), whether the received transmission frame is a parallel-off instructing transmission frame to disable the transmission/receiving or not is checked (step ST71).

If the frame is one other than the parallel-off instructing transmission frame (step ST71, negative), the NC checks the loop direction indicated by the loop direction flag in the actually received transmission frame and a loop through which the frame was actually received (step ST72), and if the two loop directions are different from each other (step ST72, affirmative), a loop direction error internal flag is turned ON (step ST74).

If the transmission frame has been received from other NC (step ST70, negative) or from the NM 20_1 (step ST70, affirmative), so long as the transmission frame is other than a parallel-off instructing transmission frame (step ST71, negative), the NC ex[illegible] processing for setting the received d[illegible] buffer of the two-port RAM 22 [illegible] loop direction err[illegible]

The N[illegible]



correctly connected (step ST79, affirmative), system control goes to step ST65.

In step ST71, in a case where a parallel-off instructing transmission frame for executing parallel-off through either one of the loops or from both of the loops is received from the NM 20_1, all the numbers of stations, in which the loop direction error has occurred, added to the parallel-off instructing transmission frame are set in the loop-directional faulty station number area of the two-port RAM 22 (step ST80), an error indicating the loop direction error is set in the status area of the two-port RAM 22 (step ST81), and the transmission/receiving start flag is disabled (step ST82).

Then the NC responds to a result of the testing sent from the NM 20_1 for checking whether the cables are correctly connected or not.

When responding to a result of the testing, at first, the NC checks whether a loop direction checking test transmission frame has been received through the main loop side (step ST83), and if the frame has been received (step ST83, affirmative), the NC checks the loop direction indicated by the loop direction flag in the actually received transmission frame and the loop through which the transmission frame was actually received (step ST84), and if it is determined that the two loops are identical (step ST84, affirmative), a loop direction testing result frame with a result of the testing as to whether [illegible] main loop direction is normal or not is transmitted to the NM 20_1 (step ST85). If it is determined that the [illegible] are not identical (step ST84, negative), a testing result frame with a result of the [illegible] abnormality in the main loop direction added [illegible] transmitted to the NM 20_1 (step ST86).

[illegible] same types of checking for the auxiliary [illegible] executed in step ST87 to step ST90.

[illegible] is executed as to whether the NC [illegible] parallel-off instructing [illegible] transmission [illegible] or [illegible] of [illegible] ing

As understood from the above description, with the communication control method in a network system according to the present invention, it is possible to check whether a cable is correctly connected thereto or not by checking a loop direction when an ordinary transmission frame is received, so that any loop error can accurately be found without requiring any particular configuration of hardware.

With the communication control method in a network system according to another feature of the invention, when a cable is not correctly connected thereto, the network manager and all the network controllers can disable a request for transmission/receiving from any of FA equipment, so that an ordinary communication with FA equipment such as a programmable controller or the like can quickly be disabled when any error occurs in any loop.

With the communication control method in a network system according to another feature of the present invention, the number of a faulty station is reported to the FA equipment connected to the network manager, so that it is possible to check which station is not correctly connected thereto with the cable, and for this reason, a recovering work of cable connection can quickly and accurately be executed.

In the communication control method in a network system according to another feature of the present invention, the number of a faulty station is reported to the FA equipment connected to the network controller, so that it is possible to check which station is not correctly connected thereto with the cable, and for this reason, a recovering work of cable connection can quickly and accurately be executed.

In the communication control method in a network system according to another feature of the present invention, it is [illegible] whether connection [illegible] cable is corrected or not by periodically executing a loop direction test after a loop error is recognized, so that checking can quickly be executed as to whether cable connection for all the stations has [illegible] state or not.

[illegible] method in a network

one skilled in the art which fairly fall within the basic teaching herein set forth.

Claims

1. A communication control method in a network system based on a duplex loop transmission system having a transmission path (30, 40) connected thereto with duplex loop arrangement, a network manager (20_1) for managing station arrangement in the loop and wiring state or the like and also for executing communication between the stations, and a plurality of network controllers (20_2 - 20_4) each for executing communications between the stations with various types of FA equipment such as a programmable controller (10, 10_1 - 10_4) connected to said network manager (20_1) and said plurality of network controllers (20_2 -20_4) respectively; wherein, when requesting transmission from the FA equipment in a station, the network manager (20_1) sets a flag indicating a transmitting direction in the loop in a transmission frame and sends the flag to other station, and the network controller (20_2 - 20_4) checks, when it receives a transmission frame with a flag indicating a loop direction set therein from the network manager (20_1), coincidence between the loop actually received and the loop direction indicated by the flag in the received transmission frame, and transmits the transmission frame including an error report indicating the loop direction to the network manager (20_1) to alert it when the loop actually received is different from the loop direction indicated by the flag.

2. A communication control method in a network system based on a duplex loop transmission system according to claim 1; wherein the network manager (20_1) checks, when it receives a transmission frame including an error report from the network controller (20_2 - 20_4), or when it receives a transmission frame with a flag set therein and indicating a loop direction of transmission from a station, coincidence between the actually received loop and the loop direction indicated by the flag in the received transmission frame, and disables a request for transmission/receiving from the FA equipment, transmits a parallel-off instructing transmission frame for reporting a wiring fault in the network to all the network controllers (20_2 - 20_4), and each network controller (20_2 - 20_4) disables a request for transmission from the FA equipment when it receives the parallel-off instructing transmission frame from the network manager (20_1) in a case where the actually received loop is different from the loop direction indicated by the flag n the received transmission frame.

3. A communication control method in a network system based on a duplex loop transmission system according to claim 1 or claim 2; wherein said transmission frame including an error report includes a number of the station in which an error has occurred, and the network manager (20_1) checks, when it receives a transmission frame including the error report from any of the network controllers (20_2 - 20_4) or when it receives a transmission flame with a flag set therein and indicating a loop direction transmitted from a station, coincidence between the loop direction actually received and the loop direction indicated by the flag in the received transmission frame, and reports the faulty station to the FA equipment in a case where the loop actually received is different from the loop direction indicated by the flag.

4. A communication control method in a network system based on a duplex loop transmission system according to claim 3; wherein said parallel-off instructing transmission frame includes a number of a station in which an error has occurred, and the network controller (20_2 - 20_4) reports the number of the faulty station to the FA equipment when it receives a parallel-off instructing transmission frame from the network controller (20_2 - 20_4).

5. A communication control method in a network system based on a duplex loop transmission system according to any of claims 2 to 4; wherein, after a parallel-off instructing transmission frame is sent to the network controller (20_2 - 20_4), the network manager (20_1) periodically transmits a loop direction testing transmission frame for testing in each line whether the wiring fault has been corrected or not to the network controller (20_2 -20_4), and the network controllers (20_2 - 20_4) check the loop direction when it receives the loop direction testing transmission frame for each line from the network manager (20_1), and transmits a loop direction testing result transmission frame indicating a result of the check to the network manager (20_1).

6. A communication control method in a network system based on a duplex loop transmission system according to claim 5; wherein the network manager (20_1) checks the loop direction testing result transmission frame from the network controller (20_2 - 20_4) for each line, and transmits a parallel-on instructing transmission frame to each network controller (20_2 - 20_4) in a case where an error in all stations including the station which has issued a request for transmission has been corrected, restarts sending a request for transmission/receiving from the FA equipment, and the network controller (20_2 - 20_4) restarts issuing a request for transmission from the FA equipment when it receives the parallel-on instructing transmission

frame.

FIG.2

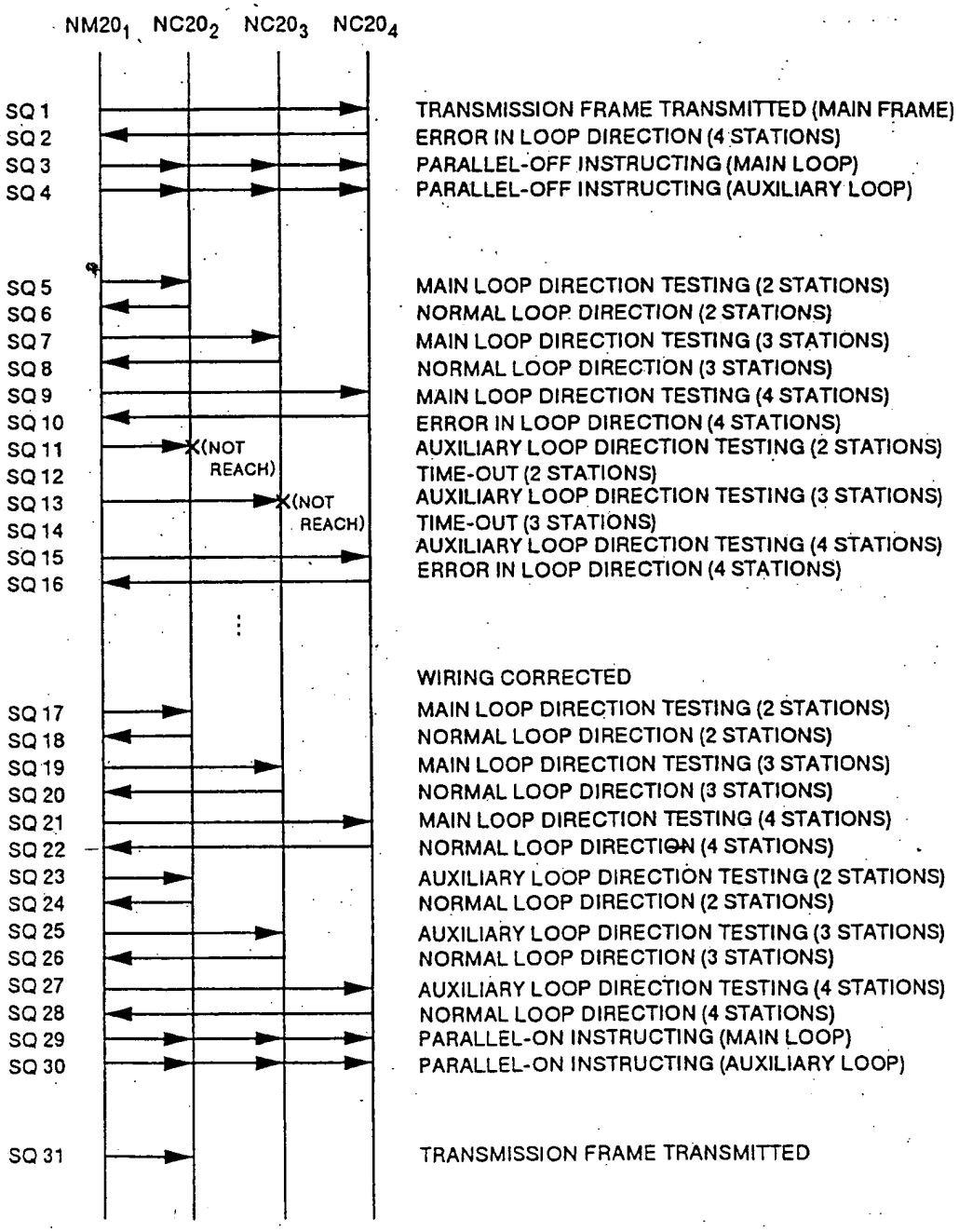

NM20$_1$
NC20$_2$
NC20$_3$
NC20$_4$
SQ 1
SQ 2
SQ 3
SQ 4
SQ 5
SQ 6
SQ 7
SQ 8
SQ 9
SQ 10
SQ 11
SQ 12
SQ 13
SQ 14
SQ 15
SQ 16
SQ 17
SQ 18
SQ 19
SQ 20
SQ 21
SQ 22
SQ 23
SQ 24
SQ 25
SQ 26
SQ 27
SQ 28
SQ 29
SQ 30
SQ 31
(NOT REACH)
(NOT REACH)
TRANSMISSION FRAME TRANSMITTED (MAIN FRAME)
ERROR IN LOOP DIRECTION (4 STATIONS)
PARALLEL-OFF INSTRUCTING (MAIN LOOP)
PARALLEL-OFF INSTRUCTING (AUXILIARY LOOP)
MAIN LOOP DIRECTION TESTING (2 STATIONS)
NORMAL LOOP DIRECTION (2 STATIONS)
MAIN LOOP DIRECTION TESTING (3 STATIONS)
NORMAL LOOP DIRECTION (3 STATIONS)
MAIN LOOP DIRECTION TESTING (4 STATIONS)
ERROR IN LOOP DIRECTION (4 STATIONS)
AUXILIARY LOOP DIRECTION TESTING (2 STATIONS)
TIME-OUT (2 STATIONS)
AUXILIARY LOOP DIRECTION TESTING (3 STATIONS)
TIME-OUT (3 STATIONS)
AUXILIARY LOOP DIRECTION TESTING (4 STATIONS)
ERROR IN LOOP DIRECTION (4 STATIONS)
WIRING CORRECTED
MAIN LOOP DIRECTION TESTING (2 STATIONS)
NORMAL LOOP DIRECTION (2 STATIONS)
MAIN LOOP DIRECTION TESTING (3 STATIONS)
NORMAL LOOP DIRECTION (3 STATIONS)
MAIN LOOP DIRECTION TESTING (4 STATIONS)
NORMAL LOOP DIRECTION (4 STATIONS)
AUXILIARY LOOP DIRECTION TESTING (2 STATIONS)
NORMAL LOOP DIRECTION (2 STATIONS)
AUXILIARY LOOP DIRECTION TESTING (3 STATIONS)
NORMAL LOOP DIRECTION (3 STATIONS)
AUXILIARY LOOP DIRECTION TESTING (4 STATIONS)
NORMAL LOOP DIRECTION (4 STATIONS)
PARALLEL-ON INSTRUCTING (MAIN LOOP)
PARALLEL-ON INSTRUCTING (AUXILIARY LOOP)
TRANSMISSION FRAME TRANSMITTED

FIG.1

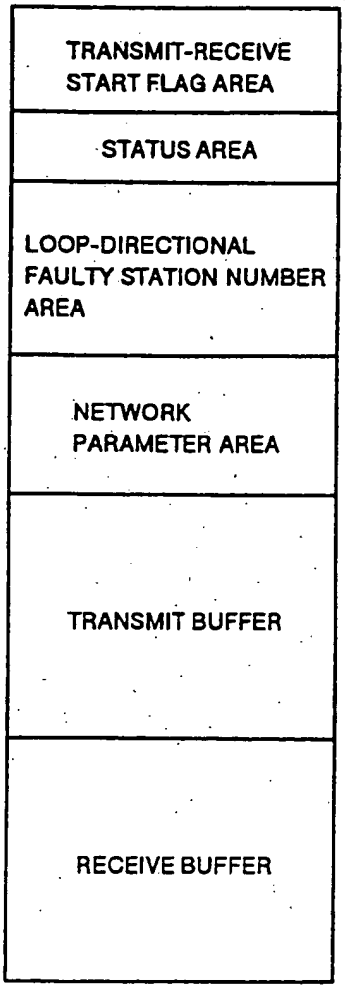

TRANSMIT-RECEIVE START FLAG AREA
STATUS AREA
LOOP-DIRECTIONAL FAULTY STATION NUMBER AREA
NETWORK PARAMETER AREA
TRANSMIT BUFFER
RECEIVE BUFFER

FIG.3

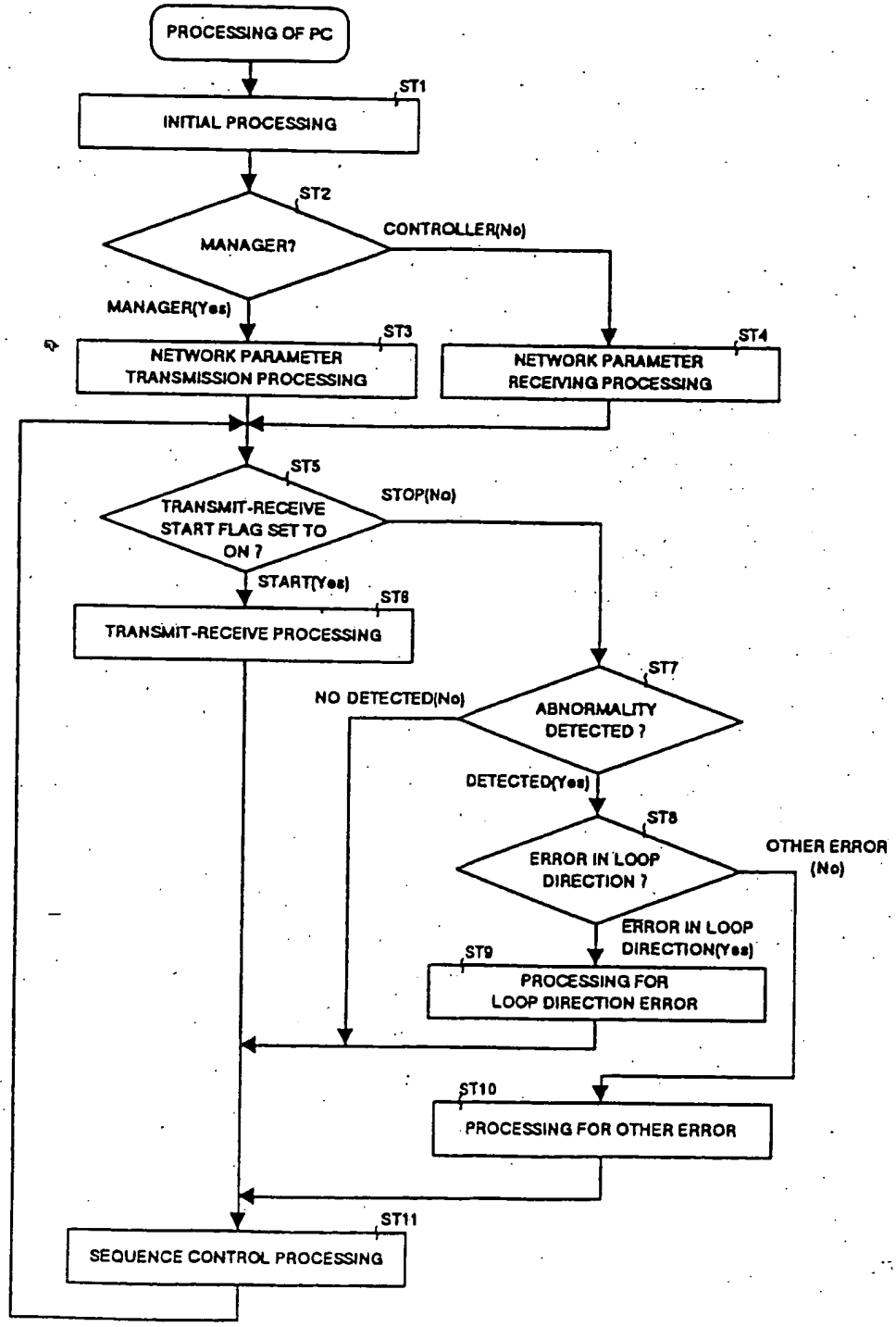

PROCESSING OF PC
ST1
INITIAL PROCESSING
ST2
MANAGER?
CONTROLLER(No)
MANAGER(Yes)
ST3
NETWORK PARAMETER TRANSMISSION PROCESSING
ST4
NETWORK PARAMETER RECEIVING PROCESSING
ST5
TRANSMIT-RECEIVE START FLAG SET TO ON ?
STOP(No)
START(Yes)
ST6
TRANSMIT-RECEIVE PROCESSING
ST7
NO DETECTED(No)
ABNORMALITY DETECTED ?
DETECTED(Yes)
ST8
ERROR IN LOOP DIRECTION ?
OTHER ERROR (No)
ERROR IN LOOP DIRECTION(Yes)
ST9
PROCESSING FOR LOOP DIRECTION ERROR
ST10
PROCESSING FOR OTHER ERROR
ST11
SEQUENCE CONTROL PROCESSING

FIG.4

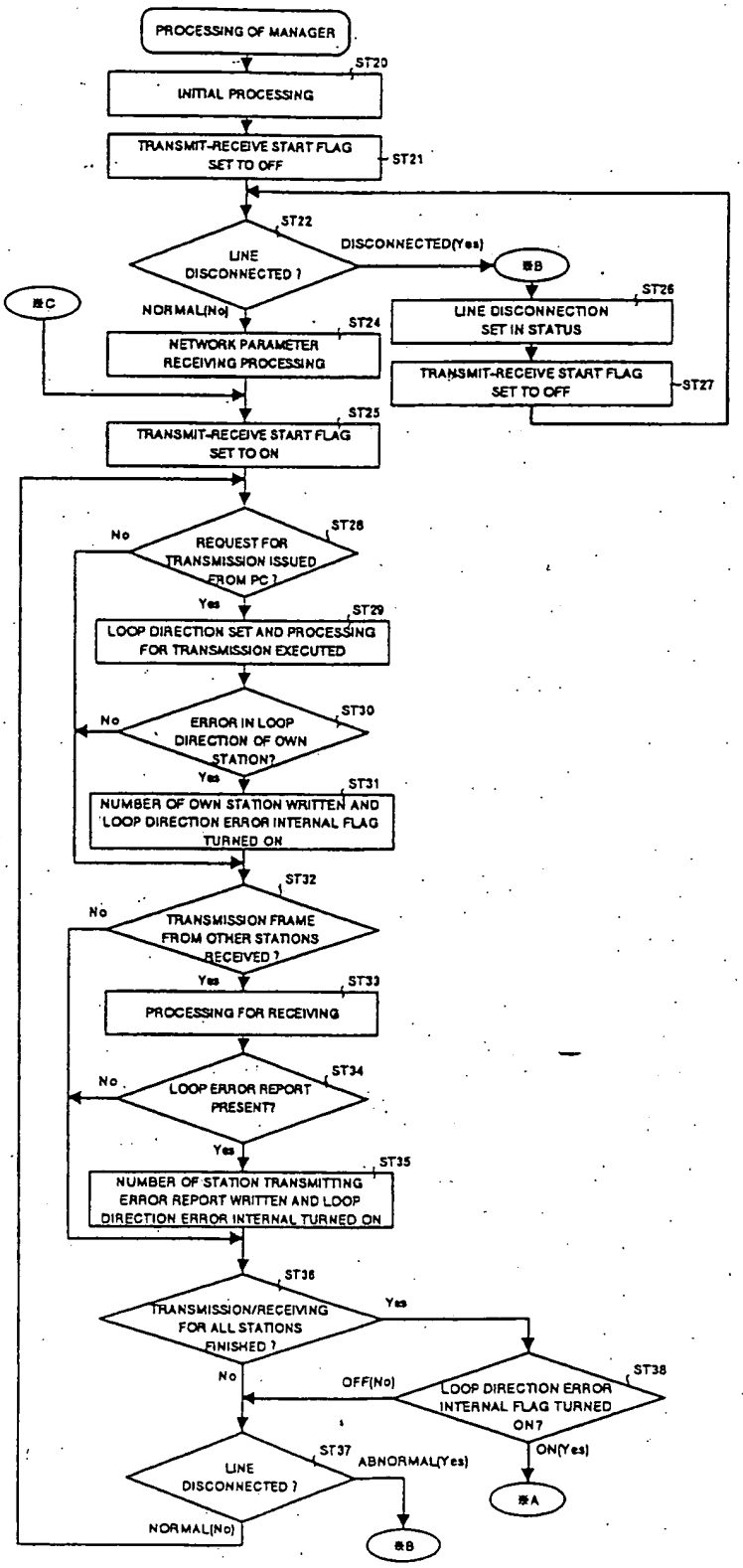

PROCESSING OF MANAGER
ST20
INITIAL PROCESSING
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST21
ST22
LINE DISCONNECTED ?
DISCONNECTED(Yes)
※B
※C
NORMAL(No)
ST24
NETWORK PARAMETER RECEIVING PROCESSING
ST26
LINE DISCONNECTION SET IN STATUS
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST27
ST25
TRANSMIT-RECEIVE START FLAG SET TO ON
ST28
No
REQUEST FOR TRANSMISSION ISSUED FROM PC ?
Yes
ST29
LOOP DIRECTION SET AND PROCESSING FOR TRANSMISSION EXECUTED
ST30
No
ERROR IN LOOP DIRECTION OF OWN STATION?
Yes
ST31
NUMBER OF OWN STATION WRITTEN AND LOOP DIRECTION ERROR INTERNAL FLAG TURNED ON
ST32
No
TRANSMISSION FRAME FROM OTHER STATIONS RECEIVED ?
Yes
ST33
PROCESSING FOR RECEIVING
ST34
No
LOOP ERROR REPORT PRESENT?
Yes
ST35
NUMBER OF STATION TRANSMITTING ERROR REPORT WRITTEN AND LOOP DIRECTION ERROR INTERNAL TURNED ON
ST36
TRANSMISSION/RECEIVING FOR ALL STATIONS FINISHED ?
Yes
No
ST38
OFF(No)
LOOP DIRECTION ERROR INTERNAL FLAG TURNED ON?
ON(Yes)
※A
ST37
LINE DISCONNECTED ?
ABNORMAL(Yes)
NORMAL(No)
※B

FIG.5

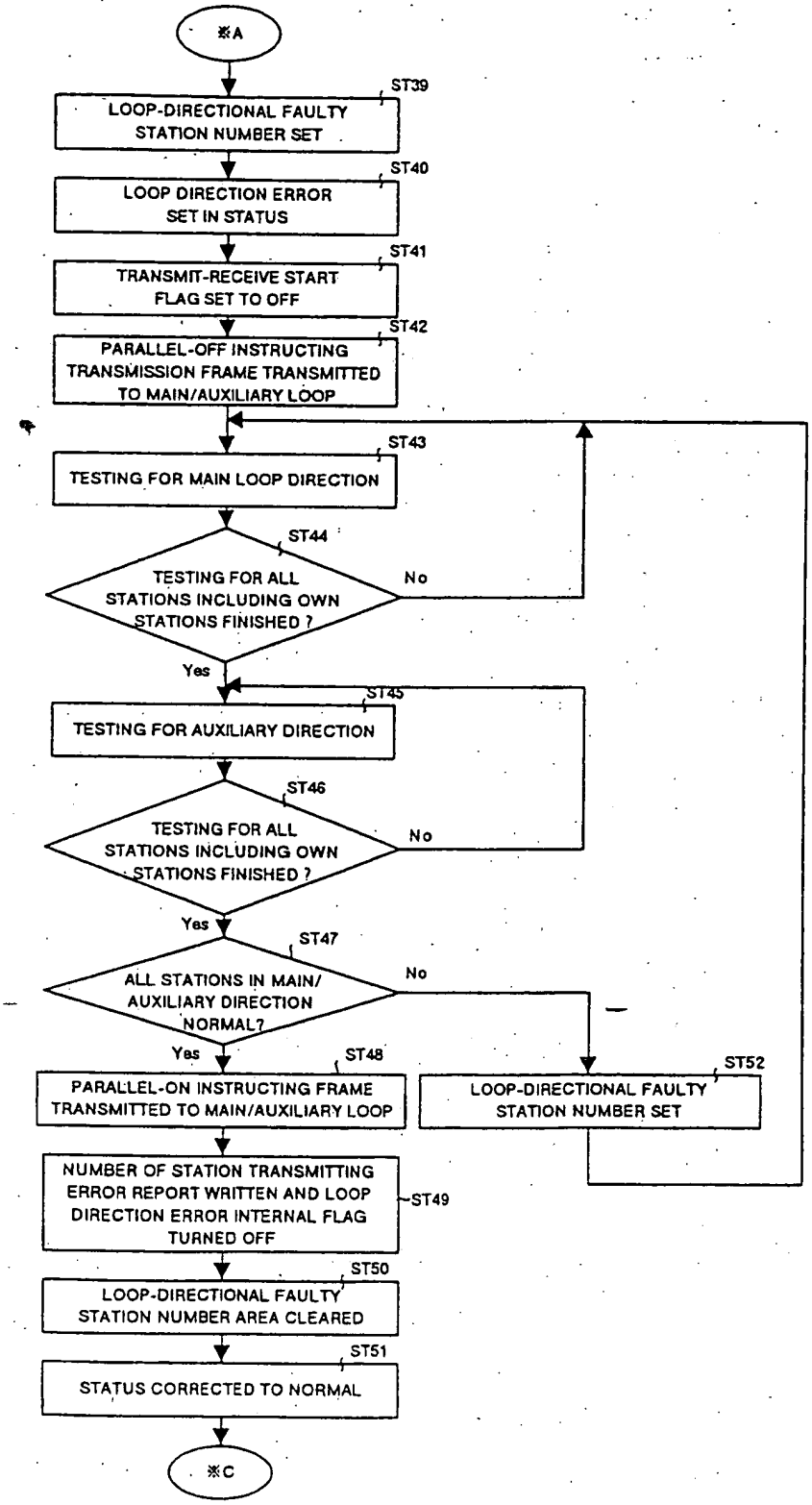

※A
ST39
LOOP-DIRECTIONAL FAULTY STATION NUMBER SET
ST40
LOOP DIRECTION ERROR SET IN STATUS
ST41
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST42
PARALLEL-OFF INSTRUCTING TRANSMISSION FRAME TRANSMITTED TO MAIN/AUXILIARY LOOP
ST43
TESTING FOR MAIN LOOP DIRECTION
ST44
TESTING FOR ALL STATIONS INCLUDING OWN STATIONS FINISHED ?
No
Yes
ST45
TESTING FOR AUXILIARY DIRECTION
ST46
TESTING FOR ALL STATIONS INCLUDING OWN STATIONS FINISHED ?
No
Yes
ST47
ALL STATIONS IN MAIN/ AUXILIARY DIRECTION NORMAL?
No
Yes
ST48
PARALLEL-ON INSTRUCTING FRAME TRANSMITTED TO MAIN/AUXILIARY LOOP
ST52
LOOP-DIRECTIONAL FAULTY STATION NUMBER SET
NUMBER OF STATION TRANSMITTING ERROR REPORT WRITTEN AND LOOP DIRECTION ERROR INTERNAL FLAG TURNED OFF
ST49
ST50
LOOP-DIRECTIONAL FAULTY STATION NUMBER AREA CLEARED
ST51
STATUS CORRECTED TO NORMAL
※C

FIG.6

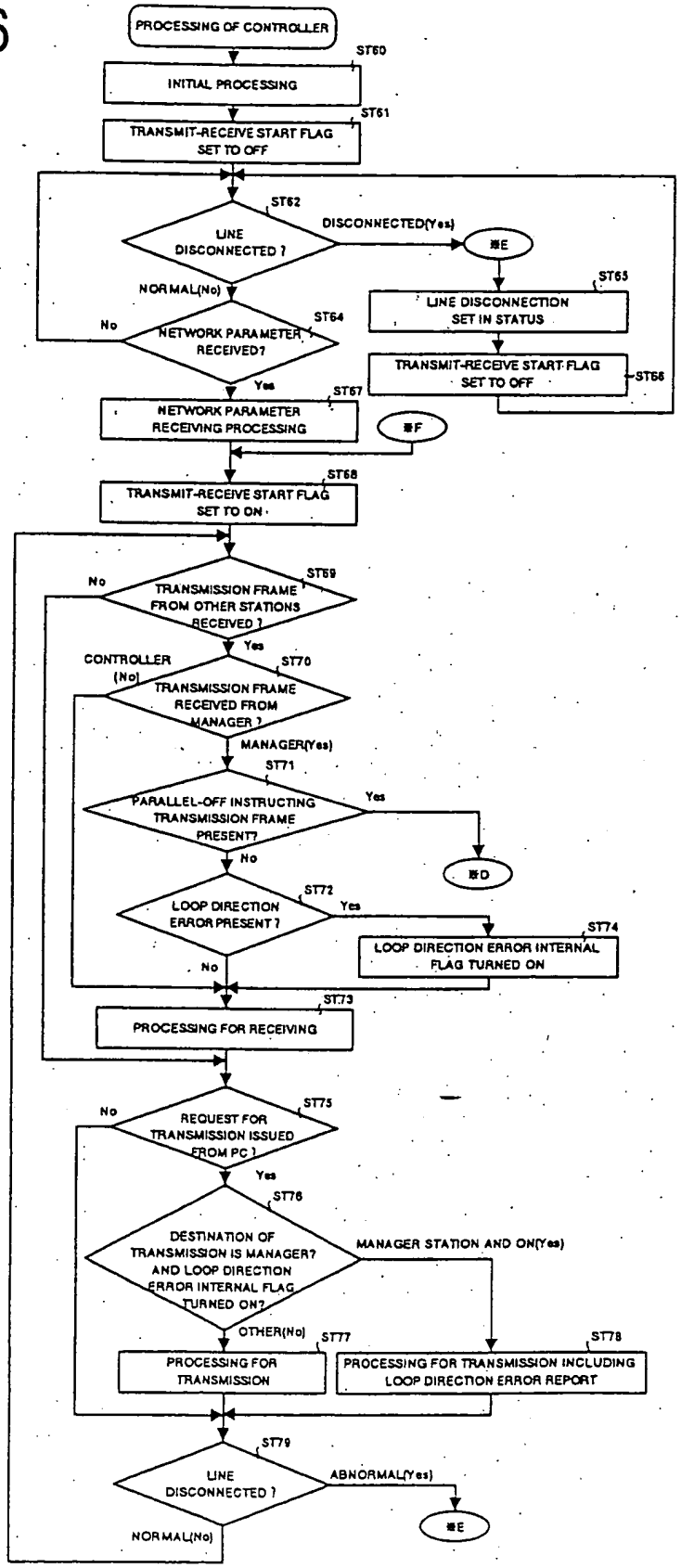
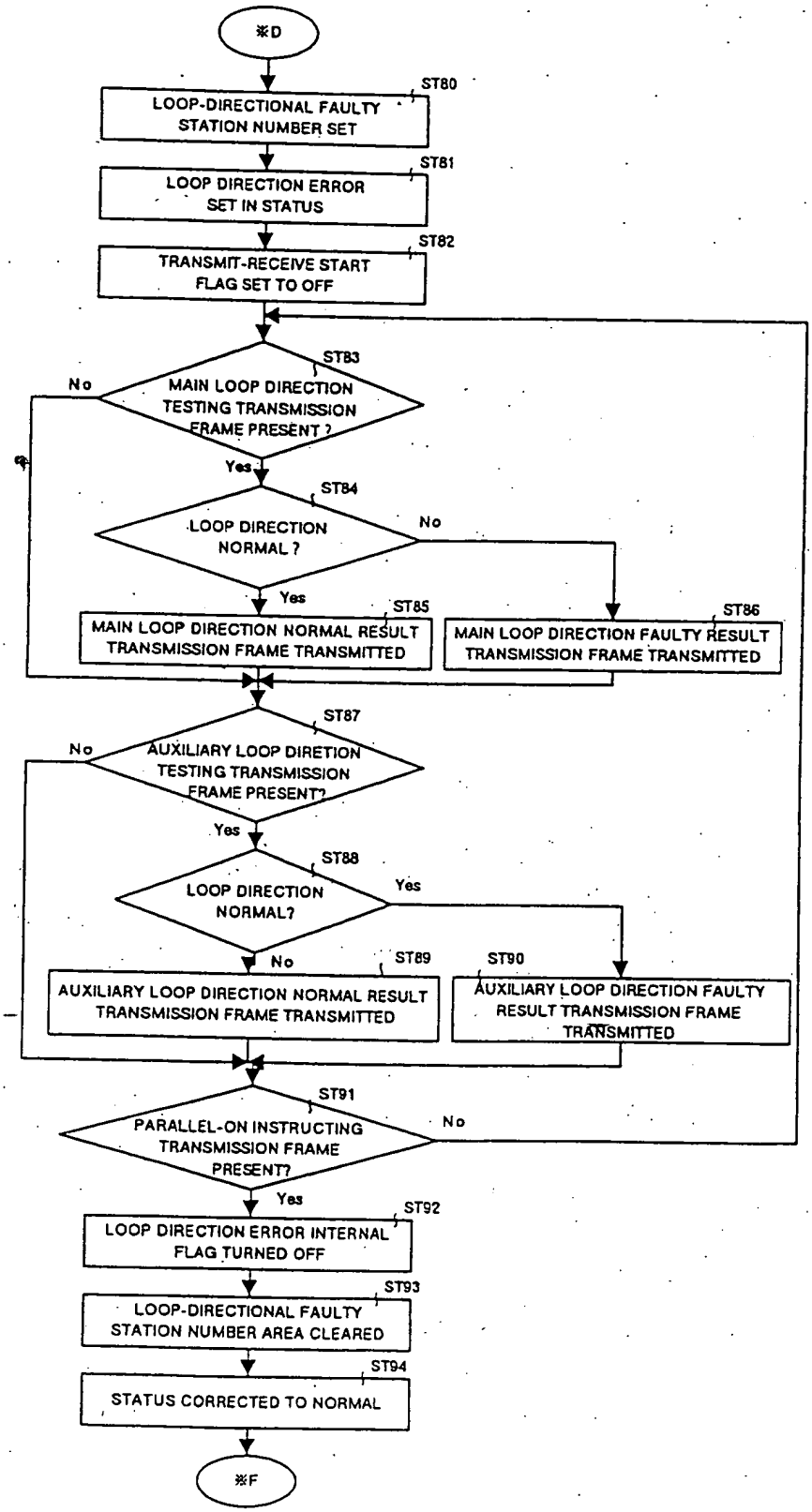

PROCESSING OF CONTROLLER
ST60
INITIAL PROCESSING
ST61
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST62
LINE DISCONNECTED ?
DISCONNECTED(Yes)
※E
ST63
LINE DISCONNECTION SET IN STATUS
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST66
NORMAL(No)
No
ST64
NETWORK PARAMETER RECEIVED?
Yes
ST67
NETWORK PARAMETER RECEIVING PROCESSING
※F
ST68
TRANSMIT-RECEIVE START FLAG SET TO ON
No
ST69
TRANSMISSION FRAME FROM OTHER STATIONS RECEIVED ?
Yes
CONTROLLER (No)
ST70
TRANSMISSION FRAME RECEIVED FROM MANAGER ?
MANAGER(Yes)
ST71
PARALLEL-OFF INSTRUCTING TRANSMISSION FRAME PRESENT?
Yes
※D
No
ST72
LOOP DIRECTION ERROR PRESENT ?
Yes
ST74
LOOP DIRECTION ERROR INTERNAL FLAG TURNED ON
No
ST73
PROCESSING FOR RECEIVING
No
ST75
REQUEST FOR TRANSMISSION ISSUED FROM PC ?
Yes
ST76
DESTINATION OF TRANSMISSION IS MANAGER? AND LOOP DIRECTION ERROR INTERNAL FLAG TURNED ON?
MANAGER STATION AND ON(Yes)
OTHER(No)
ST77
PROCESSING FOR TRANSMISSION
ST78
PROCESSING FOR TRANSMISSION INCLUDING LOOP DIRECTION ERROR REPORT
ST79
LINE DISCONNECTED ?
ABNORMAL(Yes)
※E
NORMAL(No)

FIG.7


※D
ST80
LOOP-DIRECTIONAL FAULTY STATION NUMBER SET
ST81
LOOP DIRECTION ERROR SET IN STATUS
ST82
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST83
MAIN LOOP DIRECTION TESTING TRANSMISSION FRAME PRESENT ?
No
Yes
ST84
LOOP DIRECTION NORMAL ?
No
Yes
ST85
MAIN LOOP DIRECTION NORMAL RESULT TRANSMISSION FRAME TRANSMITTED
ST86
MAIN LOOP DIRECTION FAULTY RESULT TRANSMISSION FRAME TRANSMITTED
ST87
AUXILIARY LOOP DIRETION TESTING TRANSMISSION FRAME PRESENT?
No
Yes
ST88
LOOP DIRECTION NORMAL?
Yes
No
ST89
AUXILIARY LOOP DIRECTION NORMAL RESULT TRANSMISSION FRAME TRANSMITTED
ST90
AUXILIARY LOOP DIRECTION FAULTY RESULT TRANSMISSION FRAME TRANSMITTED
ST91
PARALLEL-ON INSTRUCTING TRANSMISSION FRAME PRESENT?
No
Yes
ST92
LOOP DIRECTION ERROR INTERNAL FLAG TURNED OFF
ST93
LOOP-DIRECTIONAL FAULTY STATION NUMBER AREA CLEARED
ST94
STATUS CORRECTED TO NORMAL
※F

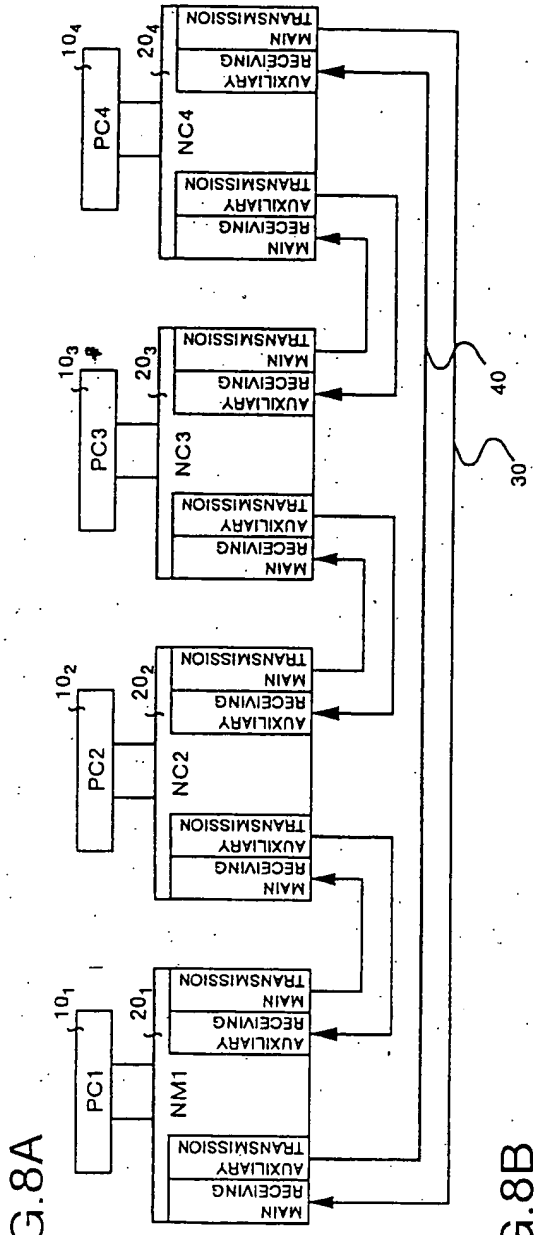

PC1
PC2
PC3
PC4
NM1
NC2
NC3
NC4
MAIN RECEIVING
AUXILIARY TRANSMISSION
AUXILIARY RECEIVING
MAIN TRANSMISSION
10
20
30
40

FIG.8A

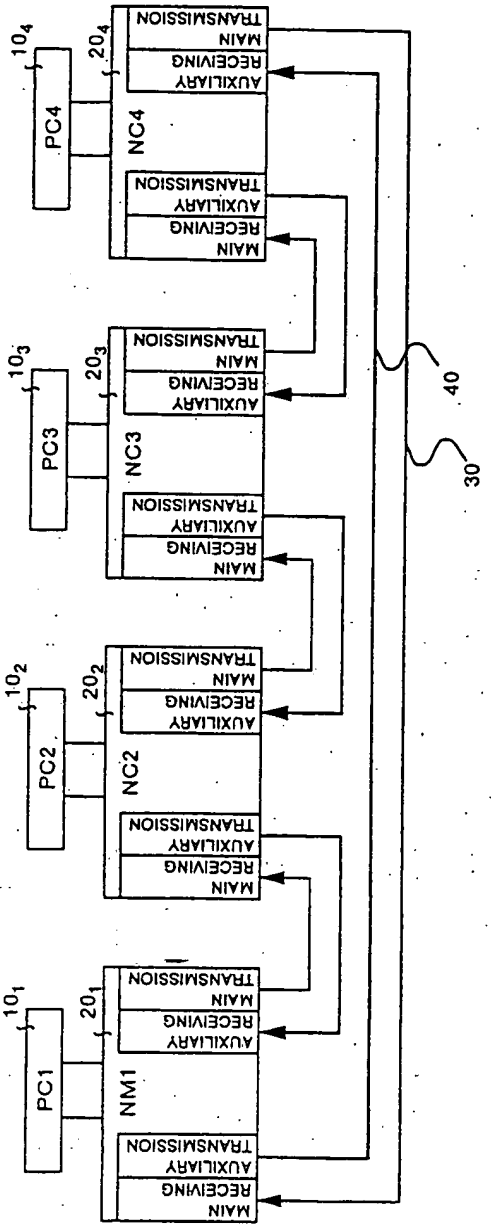

PC1
PC2
PC3
PC4
NM1
NC2
NC3
NC4
MAIN RECEIVING
AUXILIARY TRANSMISSION
AUXILIARY RECEIVING
MAIN TRANSMISSION
10
20
30
40

FIG.8B

FIG.9

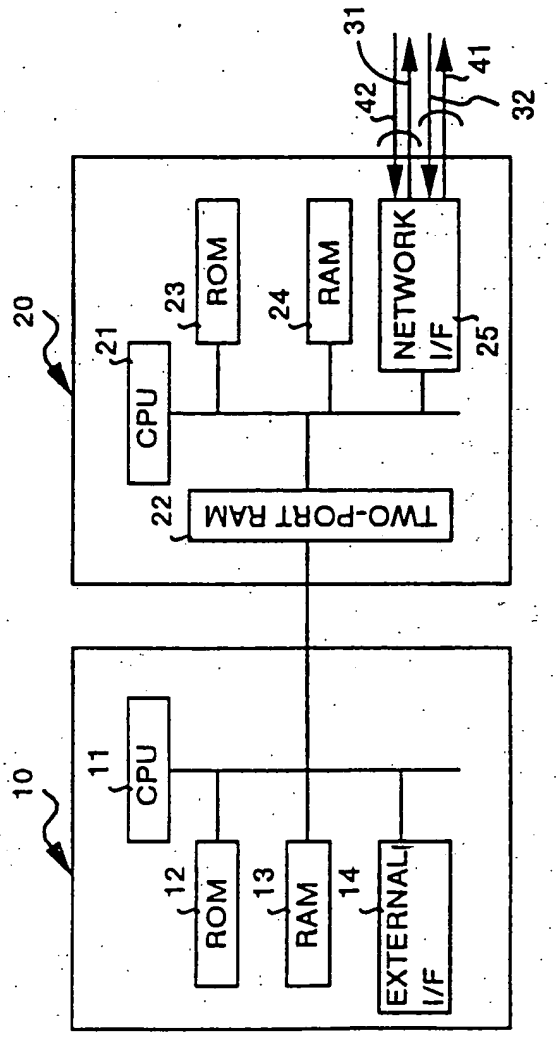

31
41
42
32
20
21
CPU
23
ROM
24
RAM
NETWORK I/F
25
22
TWO-PORT RAM
10
11
CPU
12
ROM
13
RAM
14
EXTERNAL I/F

FIG.10

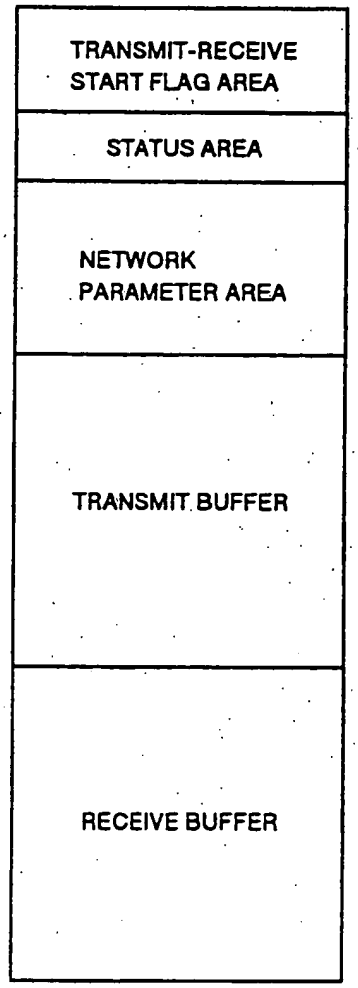

TRANSMIT-RECEIVE START FLAG AREA
STATUS AREA
NETWORK PARAMETER AREA
TRANSMIT BUFFER
RECEIVE BUFFER

FIG.11

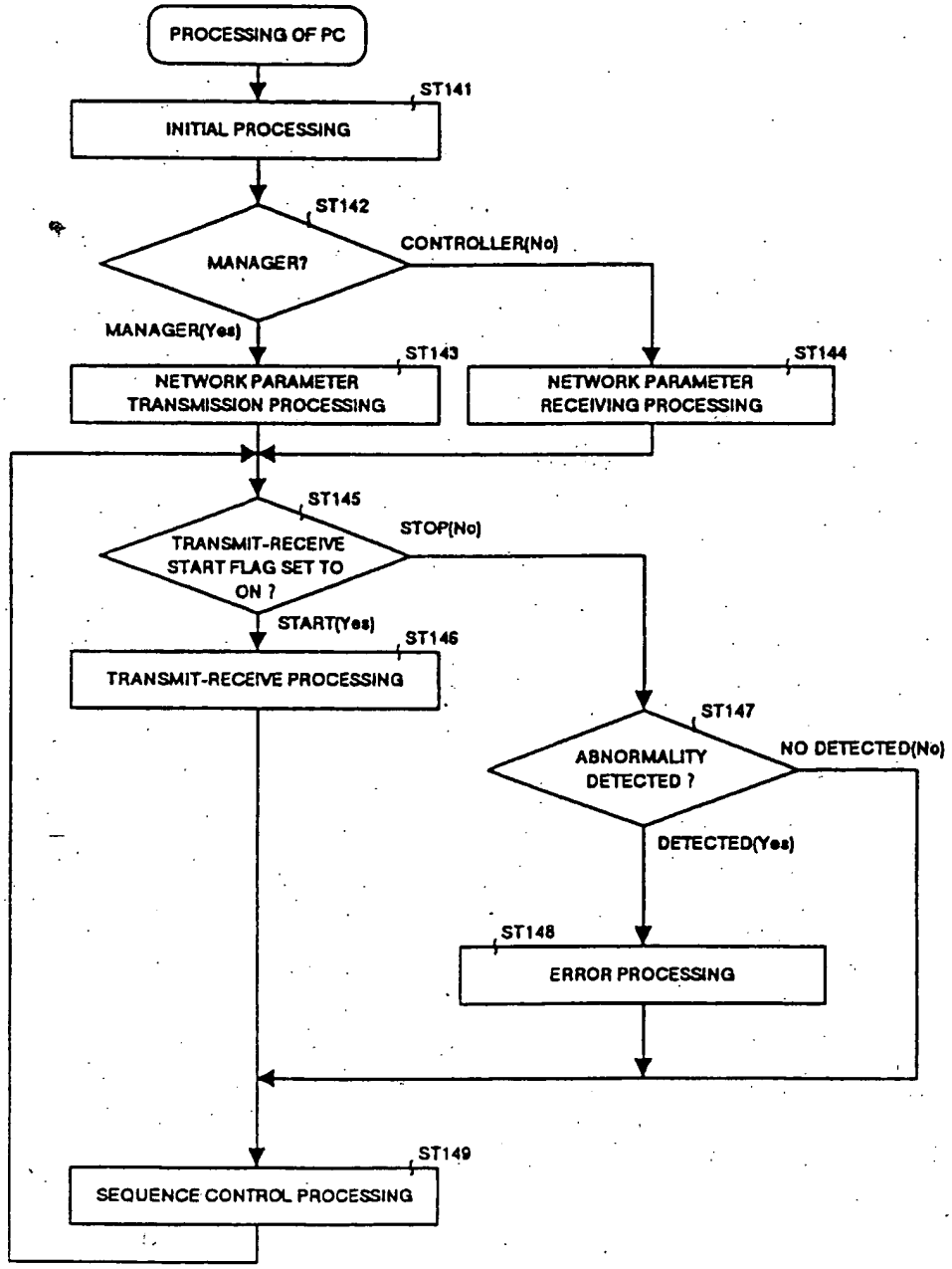

PROCESSING OF PC
ST141
INITIAL PROCESSING
ST142
MANAGER?
CONTROLLER(No)
MANAGER(Yes)
ST143
NETWORK PARAMETER TRANSMISSION PROCESSING
ST144
NETWORK PARAMETER RECEIVING PROCESSING
ST145
TRANSMIT-RECEIVE START FLAG SET TO ON ?
STOP(No)
START(Yes)
ST146
TRANSMIT-RECEIVE PROCESSING
ST147
ABNORMALITY DETECTED ?
NO DETECTED(No)
DETECTED(Yes)
ST148
ERROR PROCESSING
ST149
SEQUENCE CONTROL PROCESSING

FIG.12

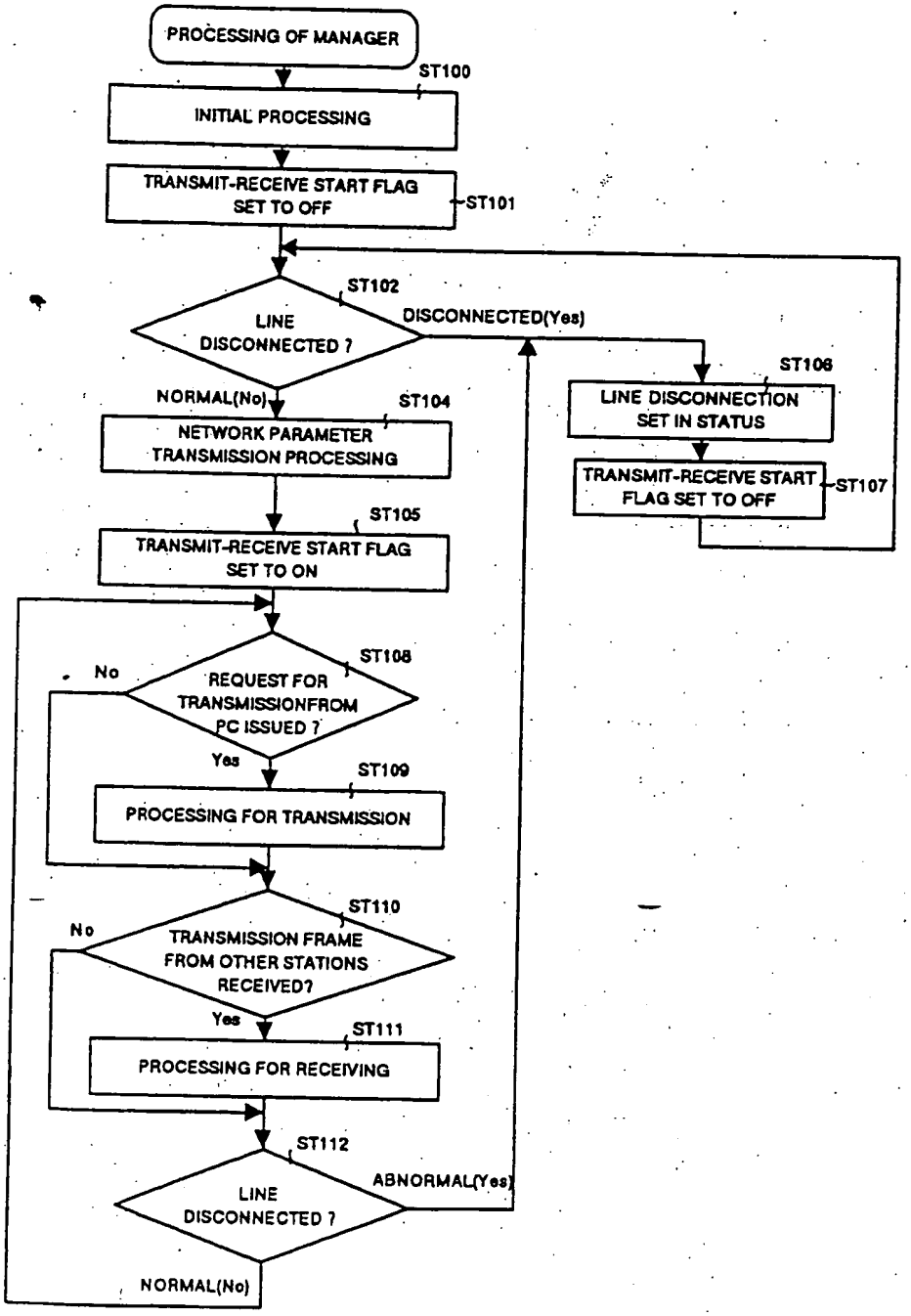
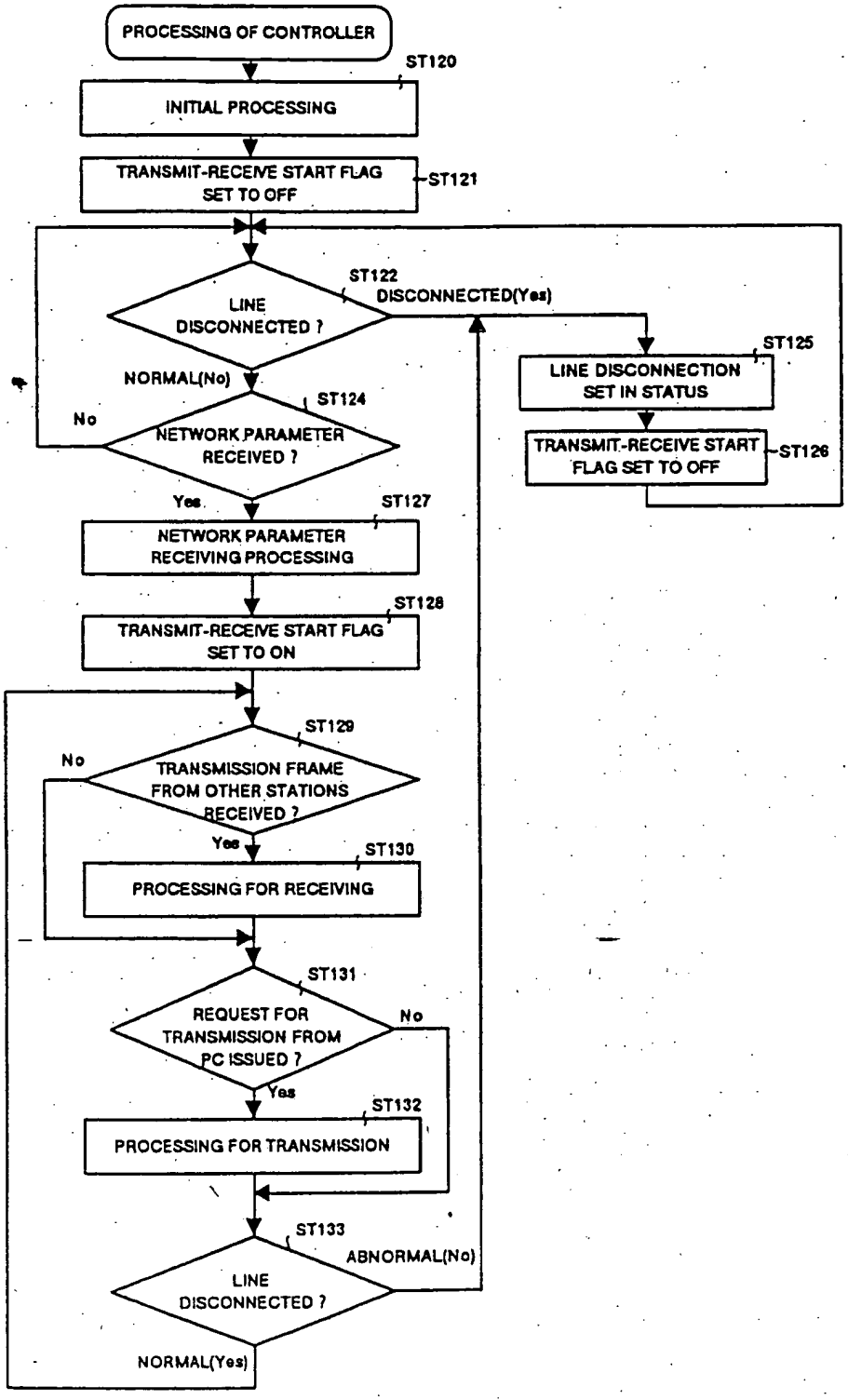

PROCESSING OF MANAGER
ST100
INITIAL PROCESSING
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST101
ST102
LINE DISCONNECTED ?
DISCONNECTED(Yes)
ST106
LINE DISCONNECTION SET IN STATUS
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST107
NORMAL(No)
ST104
NETWORK PARAMETER TRANSMISSION PROCESSING
ST105
TRANSMIT-RECEIVE START FLAG SET TO ON
ST108
No
REQUEST FOR TRANSMISSIONFROM PC ISSUED ?
Yes
ST109
PROCESSING FOR TRANSMISSION
ST110
No
TRANSMISSION FRAME FROM OTHER STATIONS RECEIVED?
Yes
ST111
PROCESSING FOR RECEIVING
ST112
LINE DISCONNECTED ?
ABNORMAL(Yes)
NORMAL(No)

FIG.13


PROCESSING OF CONTROLLER
ST120
INITIAL PROCESSING
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST121
ST122
LINE DISCONNECTED ?
DISCONNECTED(Yes)
ST125
LINE DISCONNECTION SET IN STATUS
TRANSMIT-RECEIVE START FLAG SET TO OFF
ST126
NORMAL(No)
ST124
No
NETWORK PARAMETER RECEIVED ?
Yes
ST127
NETWORK PARAMETER RECEIVING PROCESSING
ST128
TRANSMIT-RECEIVE START FLAG SET TO ON
ST129
No
TRANSMISSION FRAME FROM OTHER STATIONS RECEIVED ?
Yes
ST130
PROCESSING FOR RECEIVING
ST131
REQUEST FOR TRANSMISSION FROM PC ISSUED ?
No
Yes
ST132
PROCESSING FOR TRANSMISSION
ST133
ABNORMAL(No)
LINE DISCONNECTED ?
NORMAL(Yes)

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